

### REMARKS

By the present amendment, claims 4-6 are pending in the application.

#### Support For Claim Amendment

In claim 4, the addition of the slab composition limitation --one or more elements selected from the group consisting of Se, Sb, Cu, Nb, Cr, Sn, Ti and Bi-- is supported in the specification, e.g., at page 12, lines 12-13.

In claim 4, the location of the limitation directed to the final thickness of the sheet being 0.36 - 1.00 mm has been changed to improve clarity.

The symbol  $\Delta\theta$  for crystal orientation deviation has been inserted into claim 4.

New matter is not being presented by the present amendment.

#### §103

Claims 4-6 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,190,597 to Kobayashi et al. or U.S. Patent No. 4,979,996 to Kobayashi et al. in view of U.S. Patent No. 4,054,471 to Datta, or U.S. Patent No. 4,318,758 to Kuroki et al. and the further teaching of U.S. Patent No. 4,595,426 to Iwayama et al.

These rejections, as applied to the amended claims, are respectfully traversed.

### **Rule 132 Declaration**

In support to the patentability of the claims, enclosed is a Declaration Under 37 C.F.R. §1.132 executed by Mr. Tomoji Kumano (hereinafter "Kumano Declaration").

The Kumano Declaration addresses the critical nature of a sheet thickness of 0.36 mm.

### **The Present Invention**

The present invention and the prior art have been discussed in detail in the prior Amendment Under Rule 116 filed July 28, 2003. The discussions and argument of this prior Amendment Under Rule 116 are hereby incorporated by reference.

### **Crystal Orientation Deviation ( $\Delta\theta$ )**

The Office Action draws a comparison between US `426 (Iwayama) and  $\Delta\theta$  of the present invention, but the two clearly differ.  $\Delta\theta$  is a very important parameter of the present invention, and one that is novel and not obvious. In the specification of the present invention  $\Delta\theta$  is defined as follows.

"The deviation degree ( $\Delta\theta$ ) of crystal orientation in grains of a diameter exceeding 5 mm represents the difference in orientation in the grain in relation to that at the grain center of gravity." (Page 9, lines 4 to 7).

That is, this is the difference in orientation within the subgrain boundary of one grain. The subgrain boundary is the source of dislocations and promotes spike

domains. By facilitating domain refinement, this can reduce eddy current loss in thick grain-oriented electrical steel sheet, which is a major problem. In the case of thin grain-oriented electrical steel sheet, even when there is none of this kind of orientation deviation in the subgrain boundary, it is possible to achieve a sufficient reduction in core loss through other methods, such as the tensioning effect and the like.

$\Delta\theta$  is a special, critical factor in achieving low core loss in thick grain-oriented electrical steel sheet.

Lines 64 to 67 of column 7, US `426 (Iwayama) state that "In high-magnetic flux density grain-oriented silicon steel sheets, each crystal grain has a difference in orientation at the grain boundaries. Such a difference is approximately 4 to 5° at the maximum." That is, US `426 describes an orientation difference to 4 to 5° between crystal grains, not an orientation deviation within a single crystal grain. Which is to say, US `426 neither discloses nor suggests anything relating to  $\Delta\theta$  in accordance with the present invention.

Moreover, with respect to thick grain-oriented electrical steel sheet, it was previously thought that lowering the SF could not be expected to have much of an effect on reducing core loss. This was due to the fact that, while the core loss reducing effect of a small SF is first manifested with the effect of tension imparted to the sheet, with thick grain-oriented electrical steel sheet it

is difficult to obtain a tensioning effect. Thus, the combined effect of the  $\Delta\theta$  and SF of the present invention is extremely important. In the case of thick sheet, low core loss is obtained when  $SF < 0.8$  and  $\Delta\theta$  is  $0.2$  to  $4^\circ$ . This is not disclosed or suggested by US `426 (Iwayama).

It is also pointed out that US `426 (Iwayama) is not analogous to the present invention. US `426 (Iwayama) is directed to thin ( $0.15$  to  $0.23\text{mm}$ ) grain-oriented electrical steel sheet. US `426 (Iwayama) does not disclose or suggest nitriding after decarburation as required by the present invention. US `426 to Iwayama is very different from the present invention.

#### Sheet Thickness

The critical nature of the thickness of  $0.36\text{ mm}$  is addressed in the attached Kumano Declaration.

The Office Action cites Kuroki and Datta in saying that there is an overlap with the thickness of  $0.36$  to  $1.00\text{ mm}$ . However, these each describe just an upper limit value,  $0.020\text{ inch}$  ( $0.50\text{ mm}$ ) in the case of Datta and "not more than  $0.5\text{ mm}$ " in the case of Kuroki. In contrast, in describing the thickness of  $0.36$  to  $1.00\text{ mm}$ , the present invention defines specific upper and lower limit values, and this specific definition of the present invention has effect and meaning not disclosed or suggested by Kuroki and Datta. See Kumano Declaration.

Neither US `471 (Datta) nor US `758 (Kuroki) disclose any example of manufacturing a grain-oriented

electrical steel sheet having a sheet thickness of 0.36 to 1.00 mm. Neither US `471 (Datta) nor US `758 (Kuroki) disclose or suggest the specific range of 0.36 to 1.00 mm sheet thickness required by the present invention.

Neither US `471 (Datta) nor US `758 (Kuroki) disclose or suggest the manufacturing method of the present invention.

Neither US `471 (Datta) nor US `757 (Kuroki) disclose or suggest the slab heating temperature required by the present invention, i.e., heating the slab to a temperature not higher than 1300°C.

Neither US `471 (Datta) nor U.S. `758 (Kuroki) disclose or suggest nitriding after decarburization as required by the present invention.

The technical issues addressed in the enclosed Kumano Declaration are not disclosed or suggested by US `471 (Datta) or US `758 (Kuroki).

#### **Nitriding**

In accordance with the present invention, the steel sheet having the final thickness is nitrided following decarburization annealing.

To form a good primary recrystallization texture in the production process, it is necessary for the prior art melt to have a carbon content of 0.040 - 0.085%. In terms of the end product, this means not more than 0.0050%, so decarburization is performed in an intermediate step. Since the ease of the decarburization is inversely proportional to the square of the sheet thickness, and a tight oxidation

layer is formed during the decarburization, it has been necessary to subject thicker sheet (over 0.35 mm) to two decarburization passes, between which the sheets have to be pickled in an acid solution to remove an oxidation layer causing decarburization-difficulty. This made the production process very costly, to the extent that, in practice, it was not commercially viable. Since the ease of decarburization is inversely proportional to the square of the thickness, in terms of ease of decarburization, the difference between 0.35 mm and 0.40 mm is not 14%, but 31%  $((0.40 \text{ mm}/0.35 \text{ mm})^2 - 1)$ .

The thickness of the sheet of the present invention is 0.36 mm to 1.00 mm, so the ease of decarburization decreases compared to thinner sheet less than 0.36 mm thick.

Thus, a nitriding production method, as in the case of the present invention, enables a low slab heating temperature, so the carbon content during melt preparation can be decreased.

USP 5,190,597 to Kobayashi and USP 4,979,996 to Kokayashi describe nitriding, but the sheet thickness in each case is a maximum 0.30 mm and each describes a thickness of 0.23 mm in the Examples. There is no disclosure or suggestion in Kobayashi `597 or Kobayashi `996 to use nitriding in a method for manufacturing thick sheet.

USP 4,595,426 to Iwayama describes a thickness of 0.15 mm to 0.23 mm, and does not mention nitriding.

In the case of the present invention, subjecting the sheet to nitriding treatment following decarburization annealing is an essential element. However, USP 4,054,471 to Datta, USP 4,318,758 to Kuroki and USP 4,595,426 to Iwayama have no awareness concerning nitriding treatment, so the production process of the present invention is clearly different from these references.

USP 5,190,597 to Kobayashi and USP 4,979,996 to Kobayashi are thin materials, make no suggestion related to thick materials, and show no awareness with respect to controlling the SF and  $\Delta\theta$  values. The present invention uses the combination of SF and  $\Delta\theta$  (crystal orientation deviation) values to decrease the core loss in a thick material. Thin material technologies use, e.g., tensioning.

#### Summary

It is submitted that the Office Action is combining unrelated thick sheet technologies and thin sheet technologies in hindsight without any showing of why or how one skilled in the art would make the proposed combinations without the prior knowledge of the present invention. Even if the references are improperly combined in hindsight, there is no disclosure or suggestion of  $\Delta\theta$  and SF in accordance with the present invention.

In accordance with the present invention, an Al-containing slab is heated at a low temperature and hot-rolled and cold-rolled to obtain steel sheet having a final thickness of 0.36 to 1.00 mm. The steel sheet is subjected to decarburization annealing, followed by nitriding

treatment. The present invention controls  $\Delta\theta$  and SF to obtain a low core loss for thick grain-oriented electrical steel sheet. The present invention is a method for producing thick electrical steel sheet having excellent magnetic flux density and core loss property.

It is therefore submitted that amended independent claim 4, and claims 5 and 6 dependent thereon, are patentable over U.S. Patent No. 5,190,597 to Kobayashi et al., U.S. Patent No. 4,979,996 to Kobayashi et al. in view of U.S. Patent No. 4,054,471 to Datta, or U.S. Patent No. 4,318,758 to Kuroki et al. and the further teaching of U.S. Patent No. 4,595,426 to Iwayama et al.

CONCLUSION

It is submitted that in view of the present amendment, the Kumano Declaration and foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed to issue.

Respectfully submitted,

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